

Perfectly secure cipher system.

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Abstract

We present a perfectly secure cipher system based on the concept of fake bits which has never been used in either classical or quantum cryptography.

Cryptography, the art of secure communication has been developed since the dawn of human civilization, but it has been mathematically treated by Shannon [1]. At present, we have different classical cryptosystems whose merits and demerits are discussed below.

Vernam cipher [2]: It is proven secure [1] but it can not produce more absolutely secure bits than the shared secret bits. Due to this difficulty, it has not become popular, however it is still routinely used in diplomatic secure communication.

Data encryption standard [3] and public key distribution system [4]: These are widely used cryptosystems because they can produce more *computationally secure* bits than the shared secret bits. The problem is that its computational security is not proved. The assumption of computational security has now become weak after the discovery of fast quantum algorithms (see ref. 16)

To solve the above problems of classical cryptosystem, quantum cryptography [5-9] has been developed over the last two decades. Conceptually quantum cryptography is elegant and many undiscovered possibilities might store in it. In the last few years work on its security has been remarkably progressed [10-14], however work is yet not finished. Recently it is revealed [15] that all practical quantum cryptographic systems are insecure.

Regarding quantum cryptosystems, the popular conjectures are:

1. Completely quantum channel based cryptosystem is impossible [16] (existing quantum cryptosystem requires classical channel to operate).
2. Unconditionally secure quantum bit commitment is impossible [16].
3. By classical means, it is impossible to create more absolutely secure bits than the shared secret bits.

Recently alternative quantum cryptosystem has been developed [17-20] by the present author; which can operate solely on quantum channel (both entangled and unentangled type)[17,18] and can provide unconditionally se-

cure quantum bit commitment [19]. Here we shall see that third conjecture is also not true.

Operational procedure: For two party protocol, the problem of Vernam cipher (popularly called one time pad) [2] is that two users have to meet at regular interval to exchange the key material. We observe that key material can be simply transmitted without compromising security.

In the presented cipher system, always in the string of random bits, there are real and pseudo-bits (fake bits). Real bits contain key material and pseudo-bits are to mislead eavesdropper. Sender encodes the sequence of real bits on to the fixed real bit positions and encodes the sequence of pseudo-bits on to the fixed pseudo-bit positions. It thus forms the entire encoded sequence. which is transmitted. The fixed positions of real and pseudo-bits are initially secretly shared between sender and receiver. Therefore, receiver can decode the real bits (the first key) from real bit positions. Obviously he/she ignores the pseudo-bits.

For the second encoded sequence, sender uses new sequence of real and pseudo-bits but the position of real and pseudo-bits are same. So again receiver decodes the second key from the same real bit positions. In this way infinite number of keys can be coded and decoded. Notice that initially shared secret positions of real and pseudo-bits are repeatedly used. That's why, in some sense, secrecy is being amplified. Let us illustrate the procedure.

$$\begin{pmatrix} P & R & R & R & P & R & P & R & P & P & P & R & P & R & R & P & \dots \\ 0 & b_1 & b_1 & b_1 & 1 & b_1 & 1 & b_1 & 1 & 0 & 0 & b_1 & 0 & b_1 & b_1 & 1 & \dots \\ 1 & b_2 & b_2 & b_2 & 0 & b_2 & 0 & b_2 & 0 & 1 & 1 & b_2 & 1 & b_2 & b_2 & 0 & \dots \\ 1 & b_3 & b_3 & b_3 & 1 & b_3 & 1 & b_3 & 1 & 0 & 0 & b_3 & 0 & b_3 & b_3 & 0 & \dots \\ 0 & b_4 & b_4 & b_4 & 1 & b_4 & 0 & b_4 & 1 & 0 & 1 & b_4 & 1 & b_4 & b_4 & 0 & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ 1 & b_n & b_n & b_n & 1 & b_n & 0 & b_n & 0 & 0 & 1 & b_n & 0 & b_n & b_n & 1 & \dots \end{pmatrix} \equiv \begin{pmatrix} S_s \\ S_{e1} \\ S_{e2} \\ S_{e3} \\ S_{e4} \\ \cdot \\ \cdot \\ \cdot \\ S_{en} \end{pmatrix}$$

In the above block, the first row represents the sequence S_s , which is initially secretly shared. In that sequence, "R" and "P" denote the position of real and pseudo- bits respectively. The next rows represent the encoded sequences : $S_{e1}, S_{e2}, S_{e3}, S_{e4}, \dots, S_{en}$. In these encoding, b_i are the real bits for i -th real string of bits. Other bits are pseudo-bits. Obviously the sequences of real bits always form new real keys. Similarly sequences of pseudo-bits always form new pseudo-keys. But positions of real and pseudo-bits are unchanged. As receiver ignores pseudo-bits and pseudo-keys, so the decoded strings of real bits (keys) will look like:

$$\begin{pmatrix} R & R & R & R & R & R & R & R & \dots \\ b_1 & b_1 & b_1 & b_1 & b_1 & b_1 & b_1 & b_1 & \dots \\ b_2 & b_2 & b_2 & b_2 & b_2 & b_2 & b_2 & b_2 & \dots \\ b_3 & b_3 & b_3 & b_3 & b_3 & b_3 & b_3 & b_3 & \dots \\ b_4 & b_4 & b_4 & b_4 & b_4 & b_4 & b_4 & b_4 & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \dots \\ b_n & b_n & b_n & b_n & b_n & b_n & b_n & b_n & \dots \end{pmatrix} \equiv \begin{pmatrix} S_s \\ K_1 \\ K_2 \\ K_3 \\ K_4 \\ \cdot \\ \cdot \\ \cdot \\ K_n \end{pmatrix}$$

Here $K_1, K_2, K_3, K_4, \dots, K_N$ are independent keys.

Condition for absolute security: Shannon's condition for absolute security [1] is that eavesdropper has to depend on guess for absolutely secure system. In our system, for a particular encoded sequence of events (bits), if the probability of real events ($p_{realbits}$) becomes equal to the probability of pseudo-events ($p_{pseudo-bits}$) then eavesdropper has to guess. Since all the encoded sequences are independent so eavesdropper has to guess all sequences. Therefore, condition for absolute security can be written as: 1. $p_{pseudo-bits} \geq p_{realbits}$. 2. All encoded sequences should be statistically independent. That is, any encoded sequence should not have pseudo randomness.

Speed of communication: If we take $p_{pseudo-bits} = p_{realbits}$ and share 100 bits, then message can be communicated with 1/4 speed of digital communication (data rate will reduce a factor of 1/2 due to key production and

another factor of $1/2$ due to message encoding) as long as we wish. If the key (K_i) itself carries meaningful message, then speed of secure communication will be just half of the speed of digital communication. Perhaps no cryptosystems offer such speed.

The above art of key exchange is mainly based on the idea of pseudo-bits, which was first introduced in our noised based cryptosystem[21]. But that system will be slow and complicated. In contrast, this system will be fast and simple. Note that, noise has never been a threat to the security of any classical cryptographic protocol (rather it can be helpful [21] to achieve security). This is the main advantage of classical cryptographic protocol over quantum key distribution protocols, where noise indeed a threat to the security. It should be mentioned that the classical cipher system can not achieve other quantum cryptographic tasks such as cheating free Bell's inequality test [18] and quantum bit commitment encoding [19]. Indeed classical cryptography can not be encroach entire area of quantum cryptography.

References

- [1] Shannon, C. E. Communication theory of secrecy systems. *Bell syst. Technical Jour.* **28**, 657-715 (1949).
- [2] Vernam, G. S *J. Amer. Inst. Electr. Engrs* 45, 109-115, 1926.
- [3] Beker, J. and Piper, F., 1982, Cipher systems: the protection of communications (London: Northwood publications).
- [4] Hellman, E. M. The mathematics of public-key cryptography. *Sci. Amer.* August, 1979.
- [5] Wiesner, S. Congugate coding, Signact News, **15**, 78-88, 1983, (The manuscript was written around 1970).
- [6] Bennett, C. H. & Brassard, G. Quantum cryptography: Public key distribution and coin tossing. *In proc. of IEEE int. conf. on computers, system and signal processing* 175-179 (India, N.Y., 1984).
- [7] Ekert, A. Quantum cryptography based on Bell's theorem. *Phys. Rev. Lett.* **67**, 661-663 (1991).

- [8] Bennett, C. H. Brassard, G. & Mermin, N. D. Quantum cryptography without Bell's theorem. *Phys. Rev. Lett.* **68**, 557-559 (1992).
- [9] Bennett, C. H. Quantum cryptography using any two nonorthogonal states. *Phys. Rev. Lett.* **68**, 3121-3124 (1992).
- [10] Biham, E. & Mor, T. Security of quantum cryptography against collective attack, *Phys. Rev. Lett.* **78**, 2256-2259 (1997).
- [11] Biham, E. & Mor, T. Bounds on information and the security of quantum cryptography. *Phys. Rev. Lett.* **79**, 4034-4037 (1997).
- [12] Deutsch, D. *et al*, Quantum privacy amplification and the security of quantum cryptography over noisy channels. *Phys. Rev. Lett.* **77**, 2818-2821 (1996).
- [13] Mayers, D. Unconditional security in quantum cryptography. Preprint quant-ph/9802025.
- [14] Lo, -K. H. & Chau, H. F. Unconditional security of quantum key distribution over arbitrarily long distance. *Science*. **283**, 2050 (1999).
- [15] Brassard, G., Lutkenhaus, N., Mor, T. & Sanders, C. B. Security aspect of practical quantum cryptography. Preprint quant-ph/9911054.
- [16] Bennett, C. H. & Divincenzo, D. *Nature*, **404**, 247,2000.
- [17] Mitra, A, Complete quantum cryptography, Preprint, 5th version, quant-ph/9812087.
- [18] Mitra, A, Completely entangled based communication with security. physics/0007074.
- [19] Mitra, A, Unconditionally secure quantum bit commitment is simply possible. physics/0007089.
- [20] Mitra, A, Entangled vs unentangled alternative quantum cryptography. physics/0007090.
- [21] Mitra, A, Completely secure practical cryptography. quant-ph/ 9912074.